Texting for Taxes: Field Evidence on Loss-Framed Nudges in Japan*

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Abstract

We examine the effectiveness of loss-framed messages in promoting tax compliance among municipal delinquents in Amagasaki City, Hyogo, Japan. The City's Tax Division routinely sends text-message reminders to taxpayers who fail to pay the first installment of the Citizen's and Prefectural Citizen's Taxes. We implemented a randomized controlled trial on July 23, 2025, in which taxpayers received either the standard reminder or a loss-framed message emphasizing the potential costs of nonpayment. Logistic regression estimates based on payment outcomes as of August 13, 2025, show no statistically significant effect of the loss-framed message. However, exploratory difference-in-differences analysis using outcomes as of August 25, 2025—after an additional reminder was issued—suggests a delayed positive effect. Finally, analysis of treatment heterogeneity using Causal Forests yields no statistically significant evidence of heterogeneous treatment effects.

Keywords: Nudge, Tax Compliance, Behavioral Economics, Loss Framing, Randomized Controlled Trial
JEL classification: D91, H26, C93

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1. Introduction

Municipal resident tax is a crucial source of revenue for local governments, funding essential public services such as education, healthcare, and infrastructure. While the collection rate for current-year municipal taxes is consistently high, municipalities face a persistent challenge with delinquent taxes carried over from previous years, for which the recovery rate remains low. This discrepancy poses a practical problem: although local governments succeed in ensuring compliance in the current fiscal year, a considerable stock of arrears continues to burden municipal finances. Addressing these delinquencies requires repeated reminders and costly enforcement measures, straining limited administrative resources. Behavioral interventions, so-called "nudges," have therefore attracted attention as a potentially inexpensive tool to enhance compliance. Examining their effectiveness in the context of municipal tax collection holds direct and practical relevance for local governance.

In this paper, we collaborate with Amagasaki city, Japan, and conducted a randomized controlled trial (RCT) to examine the effectiveness of short message service (SMS) reminders targeting delinquent taxpayers. We tested the impact of a loss-framed message on tax payment behavior thereby to provide causal evidence on whether behavioral insights can improve the collection of the Citizen's and Prefectural Citizen's Tax in fiscal year 2025. Our main results are as follows:

Main Result. *As of August 13, the treatment effect of the loss-framed message was not statistically significant. However, when considering the exploratory analysis that incorporates the results of an additional demand letters sent between August 13 and 25, the loss-framed SMS was found to be effective.*

This result implies that the loss-framed reminder message does not necessarily work effectively with a single delivery, and to make such a message effective, it may require to repeat the reminder at appropriate timing.

2. Literature & Hypotheses

2.1. Literature Review

Since Allingham and Sandmo (1972), it has been considered that strengthening fines and monitoring by tax authorities plays an important role in improving tax compliance. However, there are some costs to collect the tax which is not paid. Making the costs lower, nudge is used as one of the good ways. Hallsworth et al. (2017) conducted a large-scale field experiment that applied behavioral science to tax compliance in the UK to examine the effect of different messages on the payment behavior of delinquent local taxpayers by randomly altering the wording of reminder letters. The interventions compared various frames, including messages emphasizing that tax payment is a social norm and loss-framing messages indicating the potential loss of public service funding. The results demonstrated that messages appealing to social norms had a particularly strong effect, while framing that

emphasized loss aversion was not always consistently effective. To use social norms, it is necessary to calculate the percentage of taxpayers who paid their taxes by the first deadline before sending the SMS. Since this could not be done in time, this experiment employed a loss-aversion frame. This paper will provide a perspective on how loss-framed SMS messages contribute to tax compliance.

2.2. Hypotheses

Prospect Theory (Kahneman and Tversky, 1979) suggests that individuals are more sensitive to losses than the gains of the same size. Accordingly, we hypothesize that a message emphasizing the loss from non-payment will increase the payment rate compared to a control message that only notifies of the demand letter and requests payment.

3. Experimental Design

3.1. Study Overview

This study examines the effectiveness of behavioral "nudges" in improving tax compliance in Amagasaki City, Japan. The target population was taxpayers who failed to pay the first installment of the Citizen's and Prefectural Citizen's Tax in fiscal year 2025. Individuals were randomly assigned to a control group, which received the standard reminder SMS from City Hall, or a treatment group, which received a loss-framed SMS emphasizing the costs of non-payment. Messages were sent by the City's Tax Division on around 19:00, July 23, 2025. Payment outcomes were observed on August 13 and again on August 25 for exploratory analysis. The primary outcome was payment by the second statutory deadline. Covariates include age group, gender, residence (inside/outside the city), and arrears amount. The main analysis employed logistic regression to estimate the intent-to-treat effect, while exploratory analysis used difference-in-differences to investigate delayed effects. In addition to that, we conducted heterogeneity analysis.

3.2. Experimental Messages

Specifically, we use the following messages:

Table 1 : The Detail of Messages.

Control	We recently sent a demand letter for the first installment of your inhabitant tax. The payment deadline is July 25. If you have not yet paid, please do so immediately. **-****-****(phone numbers of tax collecting division)
Treatment	【Important】Amagasaki City Tax Payment Div.: A demand letter for the first installment of your inhabitant tax has been sent. Even now, the amount of overdue tax is steadily increasing. The payment deadline is July 25. **-****-****

3.3. Data and Variables

The data were collected by staff in the City's Tax Division and provided to us in anonymized form. Both the control and treatment groups consisted of 492 observations each. The variables

include an indicator for payment status (paid or not), age, sex, amount of tax delinquency, residence status (living outside the city or not), and treatment assignment (intervened or not). These variables represent the full set of information that Amagasaki City authorized for release. Age and amount of tax delinquency are provided as categorical data. The age data were converted to continuous values by assigning the median of each age group. Although the pre-registration assumed that the amount of delinquency data would be provided as continuous values, they were instead supplied in ¥10,000 intervals to protect confidentiality, given that tax amounts are closely tied to income. We created dummy variables of sex (female dummy), residence status (outside dummy), treatment (treatment dummy) and used these variable to estimate the effects. The amount of tax delinquency was converted into dummy variables.

4. Empirical Strategy

4.1. Main Analysis (Logistic Regression)

We estimated the treatment effect of the intervention using logistic regression, following standard approaches in applied econometrics. The outcome variable was a binary indicator for payment, and the explanatory variables included a treatment dummy, age, a female dummy, amount of tax delinquency dummies, and a residence dummy indicating whether the taxpayer lived outside the city.

4.2. Exploratory Analysis (Difference-in-Differences)

To assess whether the intervention produced delayed effects, we applied a difference-in-differences approach using a linear probability model using payment outcomes observed on August 13 and August 25, 2025. Taxpayers in the treatment group who received the loss-framed message were compared with those in the control group, and the key parameter of interest captures the additional change in the payment rate among the treatment group after the second demand letters, relative to the control group. This design allows us to distinguish delayed effects of the intervention from general time trends in payment behavior.

4.3. Heterogeneity Analysis (Causal Forest)

We further examined potential treatment heterogeneity using Causal Forest, a machine learning approach developed by Wager and Athey (2018) and extended in Athey et al. (2019). This framework generalizes random forests to estimate conditional average treatment effects, enabling us to investigate whether the impact of the loss-framed SMS varied systematically across taxpayer characteristics such as age, gender, residence, and arrears amount.

5. Result

5.1. Balance Test

The results of a balance test summarized in Table 2 show that the randomization was properly implemented.

Table 2 : The Result of Balance Test.[1]

Variable	Control	Treated	p-value	Test
Age (years)	48.01 ± 14.58	46.91 ± 14.76	0.2410	t-test (means)
Female (%)	41.9%	40.4%	0.6500	Chi-squared
Outside city (%)	2.4%	4.5%	0.0809	Chi-squared
Amount class (distribution)	See detail $n = 492$	See detail $n = 492$	0.1020	Chi-squared (Monte Calro)

5.2. Main Result

We estimated two specifications using a logit model to obtain average marginal effects. The first specification includes only the treatment indicator, while the second additionally controls for age, gender, residence, and the amount of tax delinquency. Although randomization ensures that covariates are balanced, including these controls can improve the precision of the estimates and serve as a robustness check against potential imbalances. However, as summarized in Table 3, we found no evidence of a treatment effect in either specification.

Table 3 : Main Result (Average Marginal Effects).[2]

	Model 1: Intervention only			Model 2: Intervention + Covariates		
Variable	ME	SE	p-value	ME	SE	p-value
intervention	−0.037	(0.032)	0.250	−0.029	(0.032)	0.355

5.3. Exploratory Analysis

Although the pre-registered analysis with the August 13 data found no treatment effect, we conducted an exploratory analysis to assess delayed impacts. Since additional demand letters, different from the experimental messages, were sent between August 13 and 25, we applied a difference-in-differences (DiD) approach. Specifically, we include the interaction term between the intervention dummy and the August 25 dummy, which captures the effect of the second demand letters. Table 4 shows the results of the DiD analysis, which indicate that taxpayers in the treatment group were 5 percentage points more likely to pay after the second demand letters were sent, relative to the control group. This suggests that the effectiveness of loss framing may depend on both timing and repetition.

Table 4 : The Result of Exploratory Analysis.

Variable	Estimate	Std.error	p-value
DiD (post×treat)	0.051	(0.025)	0.043*

5.4. Heterogeneity Analysis

To examine heterogeneous treatment effects, we conducted a Causal Forest analysis to explore potential treatment heterogeneity. Table 5 shows the results of the test calibration[3]. The variable of "Mean forest prediction" tests whether the average of the conditional average treatment effects (hereafter, CATEs) predicted by the model equals the average treatment effect (hereafter, ATE), while the variable of "Differential forest prediction" tests whether CATEs varies with subject characteristics. Because there is no statistically significant difference between ATE and the average of CATEs predicted by the Causal Forest, CATEs estimates appear to be accurate. However, we found no statistically significant evidence of heterogeneity, indicating that treatment heterogeneity cannot be concluded. It is possible, though, the restricted sample size and covariate set constrained the Causal Forest's ability to

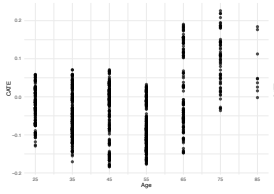
[1] The full paper will include the detailed breakdown of the amount categories.
[2] ME denotes the average marginal effect.
[3] This calibration is implemented in the grf package in R

detect meaningful heterogeneity.

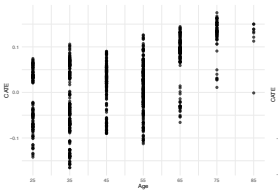
Table 5 : The Result of Test-Calibration.

Variables	Estimater		Std.error		t-value		p-value	
	August 13	August 25	August 13	August 25	August 13	August 25	August 13	August 25
Mean forest prediction	0.99210	0.86031	(1.12015)	(1.42803)	0.8857	0.6043	0.1880	0.2729
Differential forest prediction	0.13767	0.11910	(0.41431)	(0.42159)	0.3323	0.2825	0.3699	0.3888

The CATEs by age and amount of delinquent amount are shown in Figures 1 and 2, respectively. These figures suggest that, although the evidence is not statistically significant, the intervention appears to be more effective among older individuals and those with both low and high levels of tax delinquency. In addition to that, Figure 1 (B) suggests that all individuals in their seventies exhibited positive treatment effects. Moreover, Figure2 (B), taxpayers with arrears amounts of 16 or more categories consistently showed positive effects.

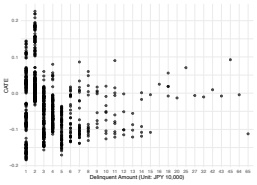


(A) Data as of August 13.

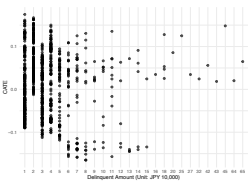


(B) Data as of August 25.

Figure 1: Conditional Average Treatment Effect by Age.



(A) Data as of August 13.



(B) Data as of August 25.

Figure 2: Conditional Average Treatment Effect by Delinquent Amount.

6. Implication

This study found that a single loss-framed SMS did not immediately improve tax compliance, but its effects emerged after a second demand letter. The additional demand letter increased payment rates among delinquent taxpayers who caught the intervention message by about 5 percentage points relative to the control group. These results suggest that loss-framed messages are more effective when combined with traditional demand letters rather than used alone. Although we found no strong evidence of heterogeneity, the gradual rise in payment rates indicates that repeated exposure may reinforce effectiveness. Overall, strategically timed behavioral nudges combined with conventional practices can enhance tax collection.

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